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## INCIDENCE, SEVERITY, AND GROWTH LOSSES ASSOCIATED WITH PONDEROSA PINE DWARF MISTLETOE ON THE LINCOLN NATIONAL FOREST, NEW MEXICO

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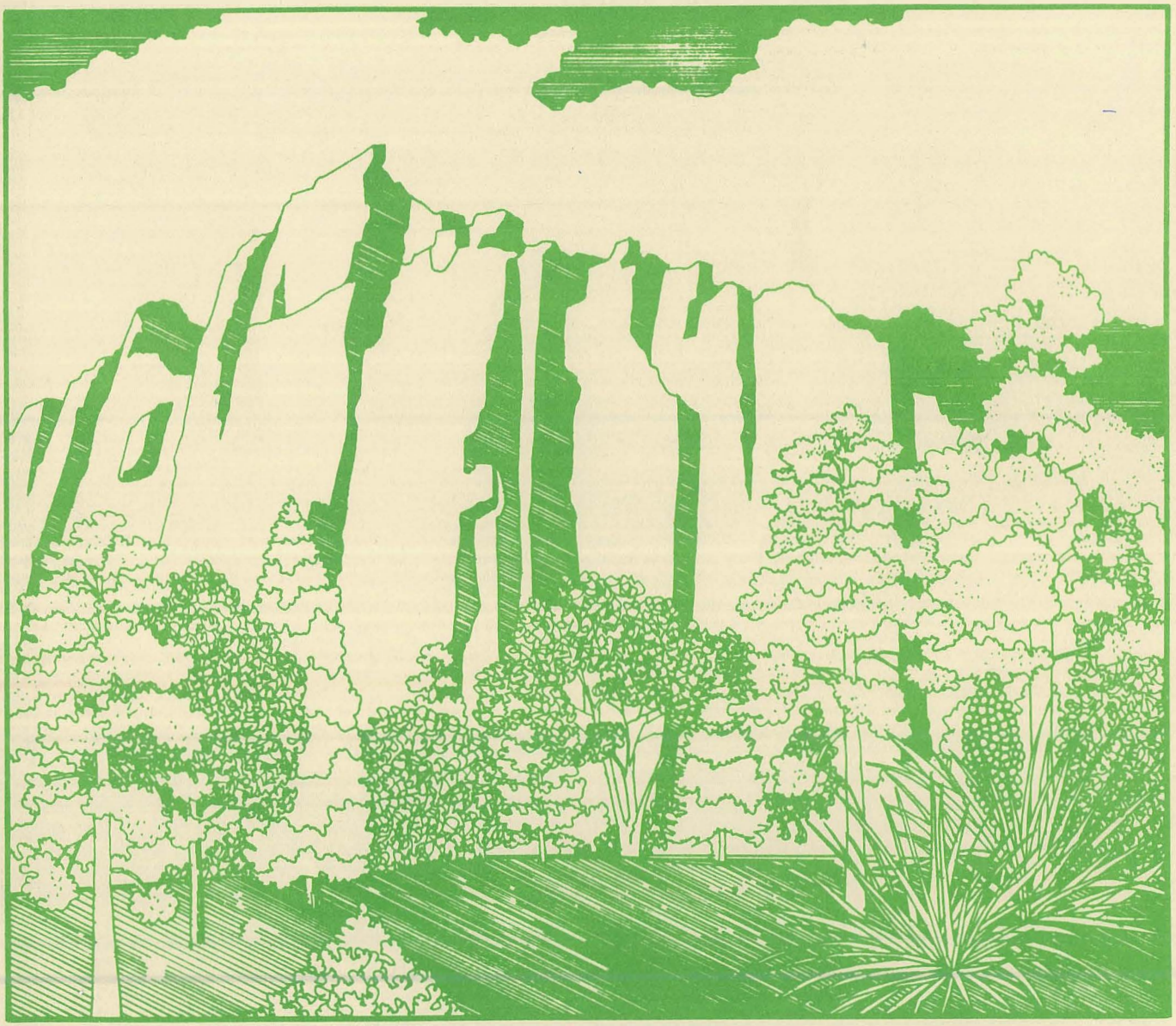

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# INCIDENCE, SEVERITY, AND GROWTH LOSSES ASSOCIATED WITH PONDEROSA PINE DWARF MISTLETOE ON THE LINCOLN NATIONAL FOREST, NEW MEXICO

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By

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## ABSTRACT

Forest stands adjacent to 77 miles of forest road were surveyed on the Lincoln National Forest in 1985 to determine the incidence and severity of dwarf mistletoe infection in the commercial ponderosa pine forest cover type. The survey data provided a basis for estimating the magnitude of growth losses associated with dwarf mistletoe. Seventy percent of the surveyed stands were mistletoe infected. Of the infected stands, 34 percent had less than one-third of the trees in the managed age class infected, 24 percent of the infected stands had one-third to two-thirds of the trees infected, and 42 percent of the stands had more than two-thirds of the trees in the managed age class infected. Forest-wide, 1,237 acres were surveyed; survey miles and acres were distributed proportionally across all stand size and visual quality classes. Chi-square analyses indicated that there were no significant relationships between stand size classes, visual quality classes, and dwarf mistletoe incidence and severity in either the District or Forest-wide analysis.

A previous Region-wide dwarf mistletoe survey, conducted between 1954-57 (Andrews and Daniels 1960), indicated that 64 percent of the ponderosa pine stands on the Lincoln National Forest were infected with dwarf mistletoe. Results from the 1985 survey indicate that dwarf mistletoe incidence has increased 6 percent in the last 25 to 30 years. At present, dwarf mistletoe incidence on the Forest is twice the Regional average.

Total growth losses were estimated using incidence and severity data from the 1985 survey and RMYLD2 growth and yield simulations. When timber management, silviculture, and dwarf mistletoe control were simultaneously optimized in the simulations, the most conservative estimate of annual loss in sawtimber at the current level of incidence was 3.3 MMBF per year. The corresponding annual loss estimate in pulpwood yield was 0.7 MMCF per year. Small changes in data input into RMYLD2 reflecting changes in timber management emphasis (i.e., focus on nontimber resource objectives), silvicultural prescriptions, and dwarf mistletoe control cutting methods, produced large increases in the annual loss estimates. Delayed stand entries produced equally large increases in the annual loss estimates. We estimate the annual losses in sawtimber growth and yield to be 6 to 9 MMBF and 1.5 to 3 MMCF, respectively.

## INTRODUCTION

Rocky Mountain ponderosa pine (Pinus ponderosa var. scopulorum engelm.) grows on an estimated 11 million acres in the Southwestern United States. In Arizona and New Mexico, 2.5 million acres are regarded as being commercially productive (growth $\geq$ 20 cubic feet per acre per year). On the Lincoln National Forest, 26 percent of the acres of commercial timberland are in the ponderosa pine forest cover type.

Region-wide, over one-third (36%) of the commercial ponderosa pine resource is infected by dwarf mistletoe (Arceuthobium vaginatum subsp. cryptopodum (Engelm.) Hawks. and Wiens); by Forest, estimates of infection levels range from 15 percent to 64 percent (Andrews and Daniels 1960). Volume losses associated with ponderosa pine dwarf mistletoe are primarily growth losses. By comparison, losses caused by other important disease pests of ponderosa pine, most notably the root rot pathogens Armillaria spp. and Heterobasidion annosum, are related to tree mortality.

The apparent increase in incidence and severity of dwarf mistletoe in southwestern ponderosa pine has been of particular concern to forest pathologists. Observations suggest that stands with histories of repeated selective harvest exhibit the greatest increase in dwarf mistletoe infection severity; data to confirm or disprove this contention have been lacking. The objectives of this evaluation were to: (1) Compare present dwarf mistletoe incidence in the ponderosa pine forest cover type with that found in the 1954-57 survey on the Lincoln National Forest, (2) determine if changes in dwarf mistletoe incidence and severity are related to stand size class or visual quality classifications, and (3) estimate annual growth losses caused by ponderosa pine dwarf mistletoe by Ranger District and Forest-wide.

## METHODS

Roadside Survey. This evaluation used the survey methods of Andrews and Daniels (1960), Merrill et al. (1985), and Johnson et al. (1984). Roadside survey-sampling methods were deemed appropriate to this problem analysis, since the spread of dwarf mistletoe is not correlated with the presence or impact of forest roading.

The survey determined dwarf mistletoe incidence and severity by combinations of forest cover type, stand size class, and visual quality class. All passable National Forest System roads on each Ranger District were surveyed. Mistletoe data were collected only from acres of ponderosa pine classified as tentatively suitable in the land management planning process. Forest cover type and stand size class of stands adjacent to roads were determined from land management planning forest cover type maps. The 16 original stand condition classes (FSH 2409.26d, dated November 1975) were condensed for simplification to form 5 broader stand size classes:

Seedlings and Saplings (SS); combining 01, 14, and 15
(>4 inches tall; <5.0 inches d.b.h.)

Poletimber (PT); combining 02, 04, 06, 08, 10, and 12
(5.0 to 8.9 inches d.b.h.)

Sawtimber (ST); combining 03, 05, 07, 09, and 13
(9.0 inches and larger)

Overmature Timber (OT); 11
(old growth)

Nonstocked (NS); 16

Sensitivity levels and visual quality objectives (FSM 2382.21; Agriculture Handbook No. 462; FSM 2383.4) were combined to reduce the number of classes, since management practices do not change significantly between some levels. The seven combined classes were:

1. Foreground Retention (FR)
2. Other Retention (OR)
3. Foreground Partial Retention (FPR)
4. Level 3 Partial Retention (3PR)
5. Other Partial Retention (OPR)
6. Level 3 Modification (3M)
7. Other Modification (OM)

Visual resource inventory maps (scale 2.64 or 2.0 inches = 1 mile) were used to indicate current boundaries of visual quality areas. Changes in forest cover type, stand size class, and visual quality class were clearly marked on survey maps and those maps are archived as a permanent record of the survey. Two-person crews drove selected roads at speeds not exceeding 10 miles per hour and observed a strip 2 chains wide, measured from the edge of the right-of-way, parallel to the right side of the road. Changes in forest cover type, stand size class, visual quality class, and dwarf mistletoe infection severity were visually estimated and recorded to the nearest 0.10 mile using the survey vehicles' odometer. Dwarf mistletoe (DM) infection severity was measured as follows:

DM0 = No visible infection in stands.

DM1 = Less than one-third of the trees in the managed age class infected.

DM2 = One-third to two-thirds of the trees in the managed age class infected.

DM3 = More than two-thirds of the trees in the managed age class infected.

At the beginning of the survey, transects 1 chain wide by 2 chains long, perpendicular to the road axis, were established every mile in which infected and uninfected trees in the managed age class were tallied to correct ocular estimates of infection severity. The number of transects gradually decreased as survey crews developed expertise in estimating infection severity.

Survey results were expressed as the ratio of miles traveled adjacent to infected stands to the total miles traveled Forest-wide, by District, stand size class, visual quality class, and dwarf mistletoe infection severity level. A record of the roads surveyed and direction traveled for each road can be found in Figures 6-10 of the Appendix.

Growth Loss Estimations. If all stands on the Forests were mistletoe free, that would represent full volume productivity or potential. It is not now, nor will it ever be, feasible to reach the mistletoe free state. It is feasible, however, to reduce mistletoe infection severity in stands so that impact on full volume productivity is negligible. The comparison of full productive potential to existing conditions is useful for assessing the magnitude of the problem. In generating sawtimber and pulpwood volume loss estimates, stands representative of the three stand size classes (i.e., seedlings and saplings, poletimber, and sawtimber, were projected to rotation age (120 years) using RMYLD2 (Edminster 1978) at the midpoint of each of the four infection severity levels.

Each stand size class was assigned a nominal age:

| | |
|---|---|
| Seedlings and Saplings | = 20 years |
| Poletimber | = 50 years |
| Sawtimber | = 100 years |
| Overmature Timber | = 200 years |

Site index values of 60, 70, and 80 feet (100-year index age) were used in the growth and yield simulations to reflect the range of conditions extant on the Forest. Growing stock levels (GSL's) were adjusted whenever possible to reflect site productivity, optimize volume production and product size, and achieve effective dwarf mistletoe control. Differences in yield for stands managed to rotation at each infection severity level represented the impact on volume production attributable to dwarf mistletoe. RMYLD2 output was expressed in yield per acre; losses were assessed by subtracting infected from healthy stand yields. Losses are reported for each District surveyed by stand size class. Acres of tentatively suitable forest land by forest cover type and stand size class were obtained from the 1985 Draft Forest Plan and were also extrapolated from the survey. From the Forest Plan the total acres of commercial ponderosa pine = 64,655 acres.

Commercial acres by stand size class:

Seedlings and Saplings = 22,765 acres (35%)

Poletimber = 26,328 acres (41%)

Sawtimber = 15,562 acres (24%)

Seedling, sapling, and poletimber stands were managed to a 120-year rotation age beginning at 20 and 50 years, respectively. For sawtimber stands, future growth losses to dwarf mistletoe were considered minor since stand regeneration was imminent. The understory seedling and sapling component was managed to rotation on RMYLD2. The underlying assumption used in sawtimber simulations was equivalent infection levels in the overstory and understory components. Optimum silvicultural prescriptions by site index, stand size class, and dwarf mistletoe infection severity level are shown in Tables 1 and 2.

For all RMYLD2 simulations, dwarf mistletoe infection severity levels were set at the midpoint of their range:

DMO = No Infection = PINF 0 ; DMLEV = 3.0

DM1 = 16.5 Percent Infection = PINF 16.5; DMLEV = 3.0

DM2 = 49.5 Percent Infection = PINF 49.5; DMLEV = 3.0

DM1 = 82.5 Percent Infection = PINF 82.5; DMLEV = 6.0

(PINF is the equivalent RMYLD2 input variable)

To arrive at estimates of potential volume production for DM3 = 82.5 percent infection, DMLEV was set at 6.0 (DMLEV is the input variable in RMYLD2 that indicates the dwarf mistletoe rating (DMR) above which thinnings will not be performed (Edminster 1978; Hawksworth 1977)).

## RESULTS

Dwarf mistletoe was found in 70 percent of the ponderosa pine stands on the Lincoln National Forest (Figure 1). Of the 77 miles surveyed, 54 miles were mistletoe infected. A total of 1,237 acres were surveyed, equal to a 2 percent sampling intensity. Dwarf mistletoe incidence and severity were twice the Regional average. Table 3 shows dwarf mistletoe incidence and severity by stand size class and District. Mistletoe incidence was greatest on the Mayhill and Cloudcroft Districts and least on the Smokey Bear District. The Guadalupe District was not surveyed because of the lack of tentatively suitable acres. Table 4 shows mistletoe infection severity combining all stands in each District; it is a condensation of Table 3. On the Mayhill and Cloudcroft Districts, 71 and 72 percent of all stands were mistletoe infected, and 44 and 61 percent of these infected stands

were more than one-third infected, respectively (Figure 1). On the Cloudcroft District 45 percent of the stands were more than two-thirds infected. Forest-wide, 75 percent of the poletimber size stands were infected with mistletoe, forewarning significant problems in the future. Similarly, 80 percent of the poletimber stands and 74 percent of the sawtimber stands were mistletoe infected on the Mayhill District. Forest-wide, the trend in seedling and sapling stands was toward reduced mistletoe infection severity (Table 3). In poletimber stands, mistletoe incidence and severity have increased appreciably (Figure 2).

Table 5 shows dwarf mistletoe incidence by visual quality class, and Table 6 gives incidence by visual quality class and infection severity level. Mistletoe was unevenly distributed with respect to visual quality classes on all Districts, but none of the differences were significant. On the Mayhill District, mistletoe incidence was greatest in stands of any age that were classified as other modification or foreground partial retention. On the Cloudcroft District, mistletoe incidence was highest in other partial retention and other modification stands of any age, and infection severity is increasing (Table 6). Forest-wide incidence in other modification stands was 91 percent; on the Mayhill and Cloudcroft Districts, incidence was 100 and 92 percent respectively.

Chi-square analyses, comparing observed and expected mistletoe infection levels by stand size and visual quality classes, revealed no significant ($P=0.05$) relationships (Table 7 and Figures 2 and 3). On the Mayhill District, mistletoe incidence was less than expected in seedling and sapling, and level 3 partial retention stands, but the differences were not significant (Figure 3 and Table 7). Incidence in Mayhill poletimber was greater than was predicted by the Chi-square distribution, but this difference was also not significant at $P=0.05$.

Estimates of annual growth loss by District are summarized in Table 8. These estimates are not based on simulating current management conditions, but are an expression of growth losses to dwarf mistletoe under the best circumstances, when silviculture and dwarf mistletoe control are optimized coincidentally and all infected stands are entered immediately. A sawtimber-loss estimate of 3.3 MMBF per year, Forest-wide, is the most conservative estimate when mistletoe incidence is 70 percent (Figure 4). Since all stands cannot be entered immediately, current sawtimber losses on the Lincoln National Forest exceed 6 MMBF per year and may run as high as 9 MMBF per year. This is confirmed in yield projects that allow delayed entry. A comparable inflation applies to cubic foot volume losses as well (i.e., 1.5-3 MMCF per year).

Based on the results of their 1954-57 mistletoe survey, Andrews and Daniels (1960) concluded that 64 percent of the commercial ponderosa pine stands on the Lincoln National Forest were infected with dwarf mistletoe. These estimates were based on a plot survey; 96 plots were taken on the forest. We analyzed the unpublished data from their roadside survey, from the same period, and found that it corroborated the results of their plot survey for the Districts they surveyed. We feel that the older plot and roadside survey information is accurate

and it serves as an appropriate yardstick upon which to evaluate the results of this current survey. Dwarf mistletoe incidence has increased from 64 to 70 percent in 25 to 30 years on the Lincoln National Forest (Figure 5).

## DISCUSSION

The results of the 1985 dwarf mistletoe survey indicate a trend of increasing incidence and severity. We attribute the increased incidence to 25 or more years of selective harvesting. The propensity to prescribe preparatory cuts in succession, where seed cuts or final removals were needed, has perpetuated uneven-aged stand conditions and increased the rate of spread of the disease. Past management emphasis was inappropriate to reducing dwarf mistletoe; cutting out the volume was most important. Trees that were selected for harvest were scattered throughout stands and usually were the largest and healthiest individuals. What remained after each selective harvest was a higher proportion of inferior quality, mistletoe-infected trees. Openings created by selective removals were naturally regenerated, stands were uneven-aged and multistoried, and dwarf mistletoe spread quickly into the new understory. We surmise that a portion of the increase in dwarf mistletoe incidence is real increase (i.e., new infection of previously healthy trees), but perhaps an equally important portion is that which has resulted from increasing the diseased proportion in stands by selective harvesting.

The increased incidence and severity of dwarf mistletoe infection on the Lincoln National Forest is worthy of considerable attention, especially since the level of incidence is easily regulated, in most cases, with appropriate cutting methods. Management objectives in the future should reflect a concerted effort to reduce dwarf mistletoe effects on growth and yield. Unchecked, the mistletoe problem will worsen and the magnitude of associated growth losses will increase. The trend can be reversed through improvement in silvicultural treatments.

In general, dwarf mistletoe spreads most slowly in single-story, even-aged stands of any age. Small departures from even-aged management result in radical increases in dwarf mistletoe incidence and severity. In the RMYLD2 growth and yield simulations that were used to estimate volume losses, stocking was drastically reduced in infected stands at the earliest possible time to reduce stand DMR's. Without this early reduction in stocking, stands were destroyed by dwarf mistletoe before rotation age. Volume loss estimates assume that thinning entries or regeneration cuts were made in every stand at the most opportune time. Departures from this management strategy resulted in reductions in timber yield much worse than reported here.

In addition to documenting mistletoe incidence, severity, and associated growth losses, it is intended that these survey results will draw to a focus the scope and principal causes of the problem, so that corrective timber management decisions can be made to reverse the trend of increasing mistletoe severity on the Forest.

The principal causes as we see them are:

1. A repeated history of selective harvesting in dwarf mistletoe-infected stands.

2. Silvicultural prescriptions that perpetuated uneven-aged stand conditions. The ponderosa pine cover type consisted of a mosaic of uneven-aged clumps of trees. Following selective overstory removals, portions of every stand were naturally regenerated. Seed cuts were rare and total overstory removals almost nonexistent.

3. Lack of priority given to treating mistletoe-infected stands. Entire timber sale areas were selectively harvested to produce a targeted volume. Little thought was given to delineating specific cutting units for the primary purpose of controlling dwarf mistletoe. By giving mistletoe-infected stands high treatment priority in timber sales, two major works could be accomplished: (a) The targeted volume could be realized from fewer acres and (b) greater volume would be produced in properly treated stands that could be harvested in subsequent entries.

4. Ineffective cutting methods when dwarf mistletoe was the intended object of silvicultural prescriptions. Visibly infected overstory trees were removed, but trees with little evidence of witches' broom formation were retained in the overstory. Seeds discharged from mistletoe plants in the residual overstory trees provided the inoculum source for further overstory and understory infections. In most cases, a seed cut and overstory removal, followed by judicious thinning in the understory, would have reduced the presence of the dwarf mistletoe in stands to acceptable levels.

5. Lack of a consistent approach or policy for controlling dwarf mistletoe in stands of any size class. Table 3 shows the breakdown of dwarf mistletoe infection severity by size class; Table 7 shows the increments and decrements. In Table 3, mistletoe incidence in seedling and sapling stands is 44 percent less than the Forest-wide mistletoe estimate. Incidence in sawtimber stands is equal to the Forest-wide estimate. Of greatest importance is the level of mistletoe incidence in poletimber Forest-wide; mistletoe incidence is 5 percent greater in poletimber than Forest-wide. Since 41 percent of the commercial land base for the Forest is in poletimber stands (see page 6), a considerable proportion of the future volume production is expected to be generated by these stands. Without proper control, that volume cannot be realized.

6. Lack of a consistent approach for controlling dwarf mistletoe in stands of any visual quality class. Table 6 shows the breakdown of dwarf mistletoe infection severity by visual quality class; Table 7 indicates the increments and decrements. The most visually sensitive visual quality class and least impacted by timber management entries is the foreground retention class. We might expect that dwarf mistletoe incidence in these stands would be greatest because they are not entered for management to retain their visual integrity. On the contrary, dwarf mistletoe incidence is lowest in foreground retention stands. We surmise that the lack of timber management

entries in these stands has reduced or eliminated the potential for mistletoe enhancement by selective harvesting. In visual quality classes where considerable stand modification is allowed or acceptable, mistletoe incidence consistently exceeds the Forest-wide average, with the exception of level 3 partial retention stands.

The growth losses estimated and presented reflect the level of damage and loss associated with mistletoe at the present level of incidence. Losses will decrease with reductions in the number and distribution of infected trees in stands. The solution to the problem lies in improving stand management by treating infected stands first, thereby reducing mistletoe incidence in stands, one stand at a time. It is important that mistletoe incidence routinely becomes a major decision variable when stand treatments are prioritized and cutting units are selected in timber sales. Prescriptions need to reflect a major emphasis of reducing stand DMR, while trying to reflect stocking, spacing, and tree diameter objectives. Dwarf mistletoe is endemic in southwestern ponderosa pine forests, but its impact can be reduced with proper management so that the effects are negligible.

Chapter 70 in the Cutting Methods Handbook (FSH 2409.26a, dated December 1984) was prepared as a field aid for dealing with mistletoe-infected stands. Information is given on rating infected trees and whole stands, and methods are presented which aid in the complex process of determining which cutting units should be entered and which can be deferred. Sections on regeneration and intermediate cutting methods are also included. Much of the time these materials will provide the necessary guidance. If additional technical assistance is needed, pathologists in the Regional Office are available to help evaluate mistletoe problems and assist in formulating prescriptions to control dwarf mistletoe in specific cutting units.

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# APPENDIX

TABLE 1.—Optimum prescriptions for RMYLD2 growth and yield simulations for the Lincoln National Forest seedlings and saplings (SS)

| SSC[1] | AGE (yrs) | SITE INDEX | DMR[2] START (0-6) | PINF[2] START % | DMR[3] FINAL (0-6) | THIN1[2] (GSL) | DSTY1[2] (GSL) | DSTY2[2] (GSL) | DBH[3] CUT (in) | DBH[3] RESID. (in) | VOLUME OUT[3] MBF/AC | VOLUME OUT[3] MCF/AC | CULM. MAI[4] AGE (yrs) | CULM. MAI[4] ft³ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SS | 20 | 60 | 0 | 0 | 0 | 60 | 60 | 60 | 19.1 | 16.6 | 15.1 | 3.5 | 100 | 27 |
| | | | 0.2 | 16.5 | 0.4 | 40 | 40 | 40 | 21.7 | 19.7 | 11.8 | 2.8 | 90 | 22 |
| | | | 0.7 | 49.5 | 0.1 | 20 | 40 | 40 | 21.9 | 19.7 | 10.9 | 2.5 | 90 | 19 |
| (Regenerate)[5] | | | 2.6 | 82.5 | 6.0 | 20 | 20 | 20 | 21.4 | 21.3 | 0.6 | 0.1 | 70 | 8 |
| SS | 20 | 70 | 0 | 0 | 0 | 60 | 70 | 70 | 19.3 | 16.7 | 20.3 | 4.6 | 100 | 36 |
| | | | 0.2 | 16.5 | 0.1 | 40 | 60 | 60 | 20.4 | 17.8 | 17.6 | 4.0 | 100 | 31 |
| | | | 0.7 | 49.5 | 0.4 | 40 | 40 | 40 | 22.9 | 20.7 | 13.7 | 3.2 | 90 | 25 |
| (Regenerate)[5] | | | 2.6 | 82.5 | 5.5 | 20 | 20 | 20 | 23.5 | 23.4 | 4.0 | 1.0 | 80 | 12 |
| SS | 20 | 80 | 0 | 0 | 0 | 60 | 70 | 70 | 20.5 | 18.0 | 25.3 | 5.6 | 100 | 43 |
| | | | 0.2 | 16.5 | 0.1 | 40 | 60 | 60 | 20.1 | 19.1 | 21.9 | 4.8 | 100 | 37 |
| | | | 0.7 | 49.5 | 0.3 | 40 | 50 | 50 | 22.6 | 20.3 | 19.4 | 4.3 | 90 | 33 |
| (Regenerate)[5] | | | 2.6 | 82.5 | 4.8 | 20 | 20 | 20 | 26.2 | 25.8 | 7.8 | 1.7 | 80 | 15 |

[1] SSC is stand size class.

[2] Input variables for data entry into RMYLD2; DMR START=DMR(1) stand dwarf mistletoe rating; PINF START=PINF(1) percent mistletoe infected; THIN1=growing stock level achieved with initial thinning; DSTY1 and 2=growing stock level achieved with subsequent entries. (Edminster 1978)

[3] Output from RMYLD2; DMR FINAL=stand dwarf mistletoe rating at rotation; DBH CUT=average diameter of sawtimber cutting during the seed cut; DBH RESID.=average residual seed tree diameter; VOLUME OUT=commercial volume produced per acre.

[4] Culmination of mean annual increment.

[5] Unable to reduce dwarf mistletoe to acceptable levels; regenerate the stand.

TABLE 2.—Optimum prescriptions for RMYLD2 growth and yield simulations for the Lincoln National Forest poletimber (PT)

| SSC[1] | AGE (yrs) | SITE INDEX | DMR[2] START (0-6) | PINF[2] START % | DMR[3] FINAL (0-6) | THIN1[2] (GSL) | DSTY1[2] (GSL) | DSTY2[2] (GSL) | DBH[3] CUT (in) | DBH[3] RESID. (in) | VOLUME CUT[3] MBF/AC | VOLUME CUT[3] MCF/AC | CULM. MAI[4] AGE (yrs) | CULM. MAI[4] $ft^3$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PT | 50 | 60 | 0 | 0 | 0 | 60 | 60 | 60 | 19.5 | 16.8 | 14.8 | 3.4 | 120 | 25 |
| | | | 0.2 | 16.5 | 0.1 | 40 | 50 | 50 | 19.3 | 16.7 | 12.1 | 3.1 | 110 | 22 |
| | | | 0.7 | 49.5 | 0.1 | 40 | 50 | 50 | 19.3 | 16.7 | 12.1 | 3.1 | 110 | 22 |
| (Regenerate)[5] | | | 2.6 | 82.5 | 4.5 | 20 | 20 | 20 | 22.3 | 21.7 | 4.9 | 1.5 | 50 | 12 |
| PT | 50 | 70 | 0 | 0 | 0 | 60 | 70 | 70 | 20.0 | 17.5 | 19.6 | 4.4 | 110 | 31 |
| | | | 0.2 | 16.5 | 0.1 | 40 | 60 | 60 | 19.5 | 16.9 | 16.7 | 4.0 | 100 | 31 |
| | | | 0.7 | 49.5 | 0.1 | 40 | 60 | 60 | 19.5 | 16.9 | 16.7 | 4.0 | 90 | 25 |
| (Regenerate)[5] | | | 2.6 | 82.5 | 3.9 | 20 | 20 | 20 | 23.5 | 22.9 | 7.0 | 2.2 | 80 | 12 |
| PT | 20 | 80 | 0 | 0 | 0 | 60 | 70 | 70 | 21.6 | 19.4 | 24.1 | 5.4 | 100 | 38 |
| | | | 0.2 | 16.5 | 0.1 | 40 | 60 | 60 | 20.5 | 18.1 | 20.0 | 5.1 | 110 | 37 |
| | | | 0.7 | 49.5 | 0.1 | 40 | 60 | 60 | 20.5 | 18.1 | 20.0 | 5.1 | 110 | 37 |
| (Regenerate)[5] | | | 2.6 | 82.5 | 2.8 | 20 | 30 | 30 | 23.1 | 21.7 | 11.6 | 3.4 | 50 | 26 |

[1]SSC is stand size class.

[2]Input variables for data entry into RMYLD2; DMR START=DMR(1) stand dwarf mistletoe rating; PINF START=PINF(1) percent mistletoe infected; THIN1=growing stock level achieved with initial thinning; STY1 and 2=growing stock level achieved with subsequent entries. (Edminster 1978)

[3]Output from RMYLD2; DMR FINAL=stand dwarf mistletoe rating at rotation; DBH CUT=average diameter of sawtimber cutting during the seed cut; DBH RESID.=average residual seed tree diameter; VOLUME CUT=commercial volume produced per acre.

[4]Culmination of mean annual increment.

[5]Unable to reduce dwarf mistletoe to acceptable levels; regenerate the stand.

TABLE 3.--Dwarf mistletoe infection severity estimates by stand size class for Districts on the Lincoln National Forest

| RANGER DISTRICT | | STAND SIZE CLASS | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | SEEDINGS/SAPLINGS | | | | POLETIMBER | | | | SAWTIMBER | | | |
| | | 0 | 1 | 2 | 3[1] | 0 | 1 | 2 | 3 | 0 | 1 | 2 | 3 |
| MAYHILL | MI[2] | 4.5 | 0.6 | | | 5.3 | 7.1 | 4.1 | 9.4 | 6.4 | 7.0 | 5.5 | 5.3 |
| | %[3] | 88 | 12 | | | 20 | 27 | 16 | 36 | 26 | 29 | 23 | 22 |
| SMOKEY BEAR | MI | | 0.1 | | | 3.6 | 2.1 | 1.6 | 3.2 | 1.4 | 0.6 | 0.5 | 1.0 |
| | % | | 100 | | | 34 | 20 | 15 | 30 | 40 | 17 | 14 | 29 |
| CLOUDCROFT | MI | 0.1 | 0.4 | | 0.5 | 1.7 | 0.5 | 0.9 | 2.8 | 0.4 | | 0.4 | 0.3 |
| | % | 10 | 40 | | 50 | 29 | 9 | 15 | 7 | 36 | | 36 | 27 |
| FOREST TOTAL | MI | 4.6 | 1.1 | | 0.5 | 10.6 | 9.7 | 6.6 | 15.4 | 8.2 | 7.6 | 6.4 | 6.6 |
| | % | 74 | 1.8 | | 8 | 25 | 23 | 16 | 36 | 29 | 26 | 22 | 23 |

[1]Dwarf mistletoe infection severity level.

[2]Miles of road surveyed in stands of particular size class and infection severity level.

[3]Percentages are computed within the stand size for a single District, and are rounded up to nearest whole percentage.

TABLE 4.--Comparison of dwarf mistletoe infection severity levels between Districts on the Lincoln National Forest.

| RANGER DISTRICT | | DWARF MISTLETOE INFECTION SEVERITY | | | | | |
|---|---|---|---|---|---|---|---|
| | | DM(-)[1] | DM(+)[2] | DM1[3] | DM2[3] | DM3[3] | SUBTOTAL |
| MAYHILL | MI[4] | 16.2 | 39.0 | 14.7 | 9.6 | 14.7 | 55.2[5] |
| | %[6] | 29 | 71 | 27 | 17 | 27 | 71[7] |
| SMOKEY BEAR | MI | 5.0 | 9.1 | 2.8 | 2.1 | 4.2 | 14.1[5] |
| | % | 35 | 65 | 20 | 15 | 30 | 18[7] |
| CLOUDCROFT | MI | 2.2 | 5.8 | 0.9 | 1.3 | 3.6 | 8.0[5] |
| | % | 28 | 72 | 11 | 16 | 45 | 10[7] |
| FOREST TOTAL | MI | 23.4 | 53.9 | 18.4 | 13.0 | 22.5 | 77.3 |
| | % | 30 | 70 | 24 | 17 | 29 | 100 |

[1](-)=Miles of ponderosa pine stands surveyed without dwarf mistletoe infection.

[2](+)=Miles of ponderosa pine stands surveyed with dwarf mistletoe infection of severity level (1, 2, or 3).

[3]Dwarf mistletoe infection severity level.

[4]Miles surveyed in stands within a District and infection severity level.

[5]Miles surveyed in a District.

[6]Percentage of total miles surveyed in a District within an infection severity level.

[7]Percentage of Forest-wide survey miles.

TABLE 5.—Dwarf mistletoe incidence by visual quality class for Districts on the Lincoln National Forest

| | | FR[1] | | OR | | FPR | | 3PR | | OPR | | 3M | | OM | | SUBTOTAL | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| RANGER DISTRICT | DM | (-)[2] | (+)[3] | (-) | (+) | (-) | (+) | (-) | (+) | (-) | (+) | (-) | (+) | (-) | (+) | (-) | (+) |
| MAYHILL | MI[4] | | | 0.7 | 1.2 | 0.2 | 1.5 | 5.8 | 8.8 | 0.2 | 0 | 9.3 | 25.5 | 0 | 2.0 | 16.2 | 39.0 |
| | %[5] | | | 32 | 63 | 12 | 88 | 40 | 60 | 100 | 0 | 27 | 73 | 0 | 100 | 29 | 71 |
| SMOKEY BEAR | MI | 1.4 | 1.3 | 0.6 | 1.8 | | | 1.0 | 1.6 | 0.4 | 0 | 1.3 | 3.6 | 0.3 | 0.8 | 5.0 | 9.1 |
| | % | 52 | 48 | 25 | 75 | | | 38 | 62 | 100 | 0 | 27 | 73 | 27 | 73 | 35 | 65 |
| CLOUDCROFT | MI | 0.1 | 0 | 0 | 0.7 | 0.5 | 0.6 | 0.6 | 0.1 | 0.6 | 2.9 | 0.3 | 0.4 | 0.1 | 1.1 | 2.2 | 5.8 |
| | % | 100 | 0 | 0 | 100 | 45 | 55 | 86 | 14 | 17 | 83 | 43 | 57 | 8 | 92 | 28 | 72 |
| FOREST TOTAL | MI | 1.5 | 1.3 | 1.3 | 3.7 | 0.7 | 2.1 | 7.4 | 10.5 | 1.2 | 2.9 | 10.9 | 29.5 | 0.4 | 3.9 | 23.4 | 53.9 |
| | % | 54 | 46 | 26 | 74 | 25 | 75 | 41 | 59 | 29 | 71 | 27 | 73 | 9 | 91 | 30 | 70 |

[1] Visual quality classes (see page 4 for an explanation of abbreviations).

[2] (-)=surveyed stands without dwarf mistletoe infection.

[3] (+)=surveyed stands with dwarf mistletoe infection of severity level 1, 2, or 3.

[4] Miles of road surveyed in stands within a District, in a given visual quality class.

[5] Percentage of total miles of road surveyed within a District, in a given visual quality class.

TABLE 6.—Comparison of dwarf mistletoe infection severity estimates by visual quality class for Districts on the Lincoln National Forest.

| RANGER DISTRICT | | ER[1] 0 | ER 1 | ER 2 | ER 3[2] | OR[1] 0 | OR 1 | OR 2 | OR 3 | FPR[1] 0 | FPR 1 | FPR 2 | FPR 3 | RPR[1] 0 | RPR 1 | RPR 2 | RPR 3 | OPR[1] 0 | OPR 1 | OPR 2 | OPR 3 | RM[1] 0 | RM 1 | RM 2 | RM 3 | OM[1] 0 | OM 1 | OM 2 | OM 3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MAYHILL | MI[3] | | | | | 0.7 | 0.2 | 0.4 | 0.6 | 0.2 | 0.8 | 0.3 | 0.4 | 5.8 | 4.0 | 2.4 | 2.4 | 0.2 | 0 | 0 | 0 | 9.3 | 9.4 | 6.1 | 10.0 | 0 | 0.3 | 0.4 | 1.3 |
| | %[4] | | | | | 37 | 11 | 21 | 32 | 12 | 47 | 18 | 24 | 40 | 27 | 16 | 16 | 100 | 0 | 0 | 0 | 27 | 27 | 18 | 29 | 0 | 15 | 20 | 65 |
| SMOKEY BEAR | MI | 1.4 | 0 | 0.3 | 1.0 | 0.6 | 0.6 | 0.9 | 0.3 | | | | | 1.0 | 0.3 | 0.3 | 1.0 | 0.4 | 0 | 0 | 0 | 1.3 | 1.2 | 0.5 | 1.9 | 0.3 | 0.7 | 0.1 | 0 |
| | % | 52 | 0 | 11 | 37 | 25 | 25 | 38 | 13 | | | | | 38 | 12 | 12 | 38 | 100 | 0 | 0 | 0 | 27 | 24 | 10 | 39 | 27 | 64 | 9 | 0 |
| CLOUDCROFT | MI | 0.1 | 0 | 0 | 0 | 0 | 0 | 0.5 | 0.2 | 0.5 | 0 | 0.4 | 0.2 | 0.6 | 0 | 0.1 | 0 | 0.6 | 0.5 | 0 | 2.4 | 0.3 | 0 | 0.1 | 0.3 | 0.1 | 0.4 | 0.2 | 0.5 |
| | % | 100 | 0 | 0 | 0 | 0 | 0 | 71 | 29 | 45 | 0 | 36 | 18 | 86 | 0 | 14 | 0 | 17 | 14 | 0 | 69 | 43 | 0 | 14 | 43 | 8 | 33 | 17 | 42 |
| FOREST TOTAL | MI | 1 | 0 | 0.3 | 1.0 | 1.3 | 0.8 | 1.8 | 1.1 | 0.7 | 0.8 | 0.7 | 0.6 | 7.4 | 4.3 | 2.8 | 3.4 | 1.2 | 0.5 | 0 | 2.4 | 10.9 | 10.6 | 6.7 | 12.2 | 0.4 | 1.4 | 0.7 | 1.8 |
| | % | 54 | 0 | 11 | 36 | 26 | 16 | 36 | 22 | 25 | 29 | 25 | 21 | 41 | 24 | 16 | 19 | 29 | 12 | 0 | 59 | 27 | 26 | 17 | 30 | 9 | 33 | 16 | 42 |

[1] Visual quality classes (see page 4 for an explanation of abbreviations).

[2] Dwarf mistletoe infection severity level.

[3] Miles of road surveyed in stands of particular size class and infection severity level.

[4] Percentages are computed within the stand size for a single District, and are rounded up to nearest whole percentage.

TABLE 7.--Summary of Chi-square analyses comparing observed and expected mistletoe incidence[1].

| | | STAND SIZE CLASS | | | VISUAL QUALITY CLASSES | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| RANGER DISTRICT | | SS[2] | PT[2] | ST[2] | FR[3] | QR[3] | FPR[3] | 3PR[3] | OPR[3] | 3M[3] | QM[3] |
| MAYHILL ($O_1$-$E_1$) | MI[4] | -3.0 | +2.2 | +0.6 | | -0.2 | +0.3 | -1.6 | | +0.8 | +0.6 |
| | SIG[5] | NS | NS | NS | | NS | NS | NS | | NS | NS |
| SMOKEY BEAR | MI | 0 | +0.1 | -0.2 | -0.5 | +0.2 | | -0.1 | -0.3 | +0.4 | +0.1 |
| | SIG | NS | NS | NS | NS | NS | | NS | NS | NS | NS |
| CLOUDCROFT | MI | +0.2 | -0.1 | -0.1 | -0.1 | +0.2 | -0.2 | -0.4 | +0.4 | -0.1 | +0.2 |
| | SIG | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS |
| FOREST TOTAL | MI | -2.7 | +2.1 | +0.4 | -0.2 | +0.2 | +0.1 | -2.0 | 0 | +1.3 | +0.9 |
| | SIG | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS |

[1]Dwarf mistletoe incidence is presented as miles of stands surveyed with any mistletoe infection, by stand size class, visual quality class, and District.

[2]SS=seedling and sapling stands; PT=poletimber stands; ST=sawtimber stands; OT=overmature stands.

[3](See page 4 for an explanation of abbreviations.)

[4]Difference between the observed ($O_1$) number of miles of road surveyed with mistletoe infection and the expected ($E_1$) number of miles with mistletoe infection as predicted by the Chi-square distribution.

[5]Denotes significance at P=0.05; NS is not significant; S is significant.

TABLE 8.--Minimum estimate[1] of annual losses in sawtimber and pulpwood production on the Lincoln National Forest.

| RANGER DISTRICT | | SEEDLINGS AND SAPLINGS (SS) MMBF/YR | SEEDLINGS AND SAPLINGS (SS) MMCF/YR | POLETIMBER (PT) MMBF/YR | POLETIMBER (PT) MMCF/YR | SAWTIMBER (ST) MMBF/YR | SAWTIMBER (ST) MMCF/YR | SUBTOTAL MMBF/YR | SUBTOTAL MMCF/YR |
|---|---|---|---|---|---|---|---|---|---|
| MAYHILL | VOL. | 0.4 | 0.01 | 0.8 | 0.13 | 0.4 | 0.1 | 1.24 | 0.24 |
| | %[2] | 3 | 4 | 65 | 54 | 32 | 42 | 38 | 34 |
| SMOKEY BEAR | VOL. | 0.2 | 0.05 | 0.9 | 0.2 | 0.4 | 0.1 | 1.5 | 0.35 |
| | % | 13 | 14 | 60 | 57 | 27 | 29 | 46 | 50 |
| CLOUDCROFT | VOL. | 0.4 | 0.09 | 0.08 | 0.01 | 0.07 | 0.01 | 0.55 | 0.11 |
| | % | 73 | 82 | 15 | 9 | 13 | 9 | 17 | 16 |
| FOREST TOTAL | VOL. | 0.64 | 0.15 | 1.78 | 0.34 | 0.87 | 0.21 | 3.29 | 0.7 |
| | % | 19 | 21 | 54 | 49 | 26 | 30 | 100 | 100 |

[1]Estimates based on RMYLD2 growth and yield projections using incidence severity data from the survey.

[2]Percentage of District losses in a stand size class.

FIGURE 1. Comparison of DM Incidence between Districts and the trend towards increased infection severity

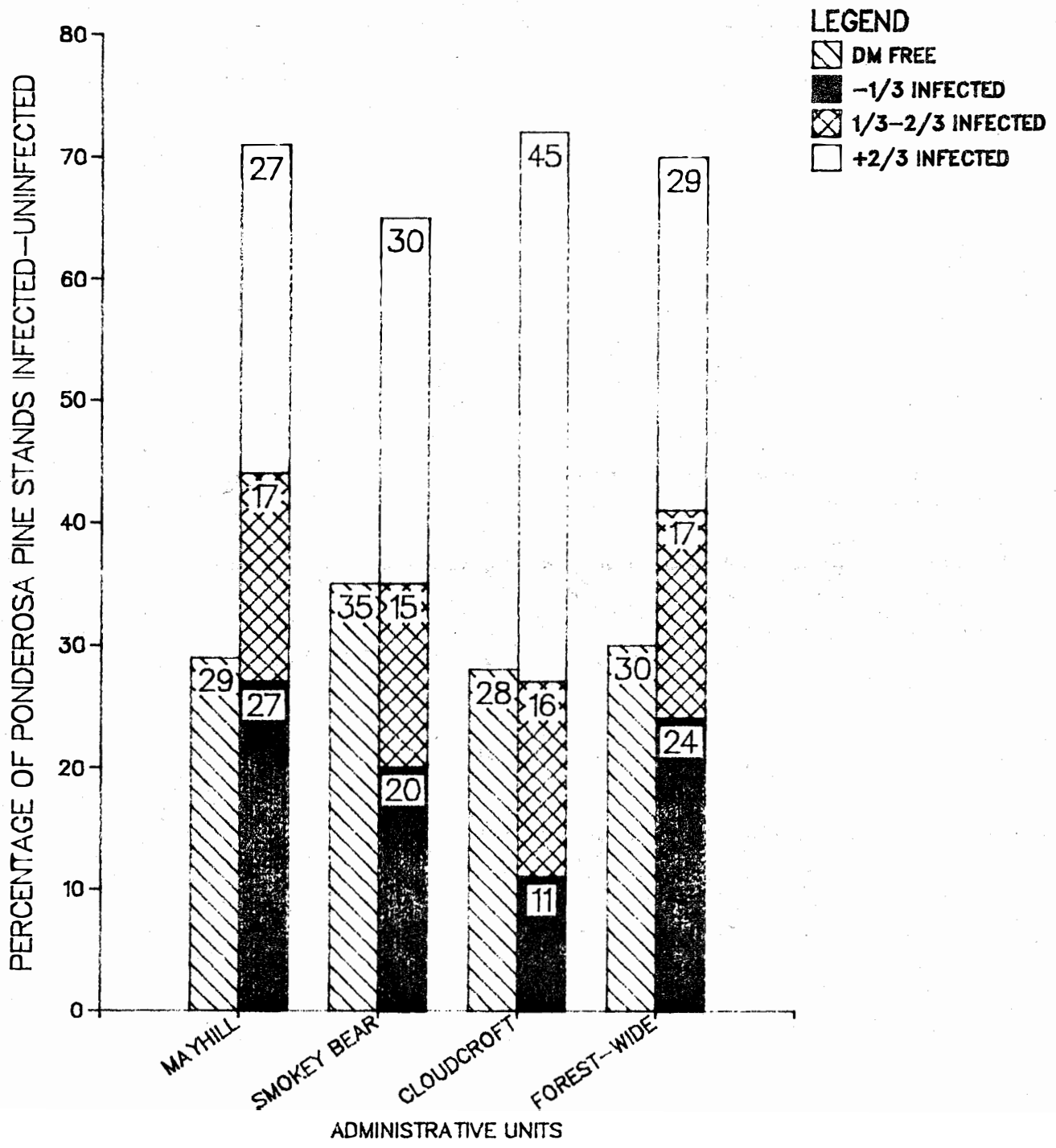


FIGURE 2. Comparison of observed and expected DM incidence by size class for the Lincoln National Forest

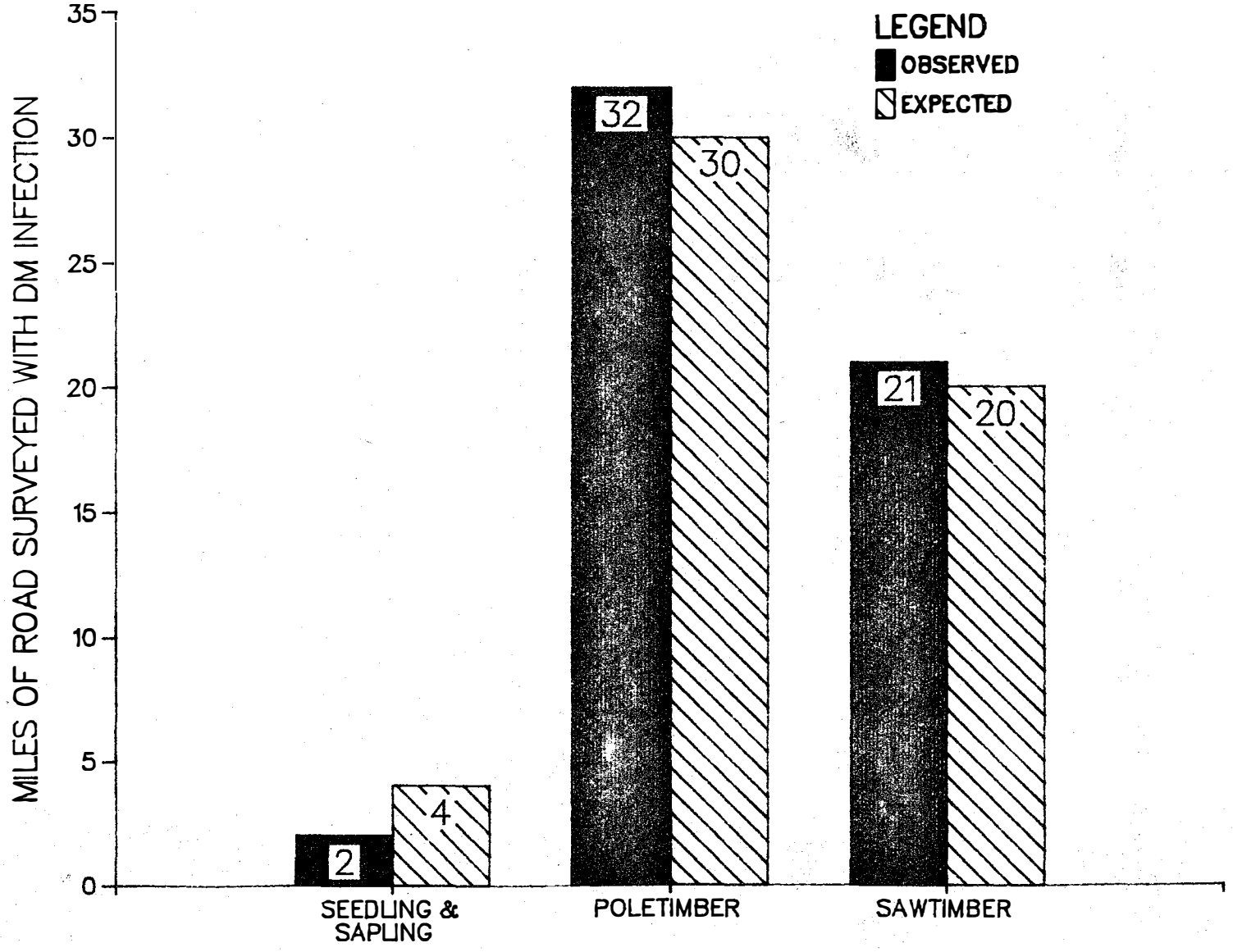


FIGURE 3. Comparison of observed and expected DM incidence by visual quality class for the Lincoln National Forest

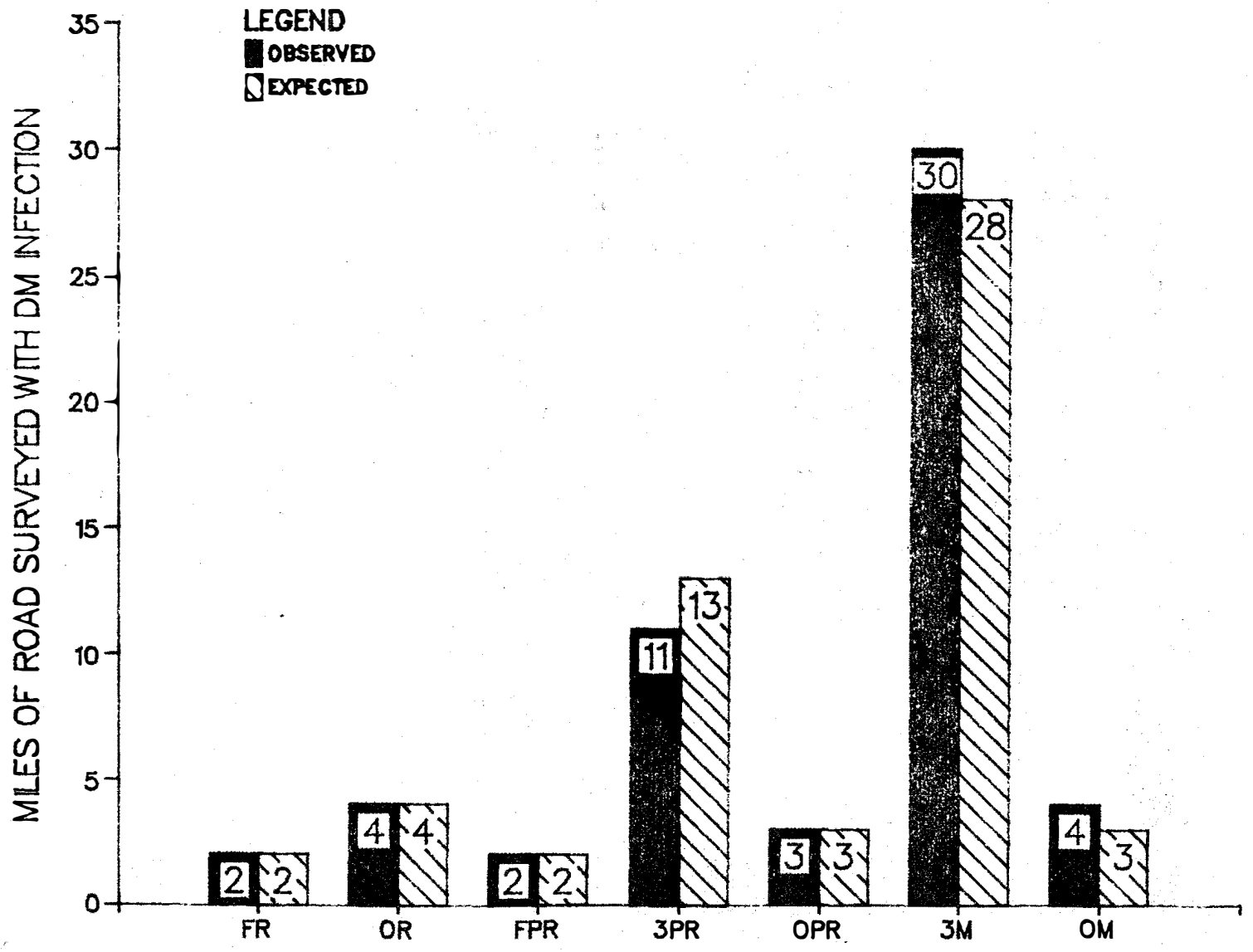


FIGURE 4. Distribution of projected annual volume losses by size class for the Lincoln National Forest

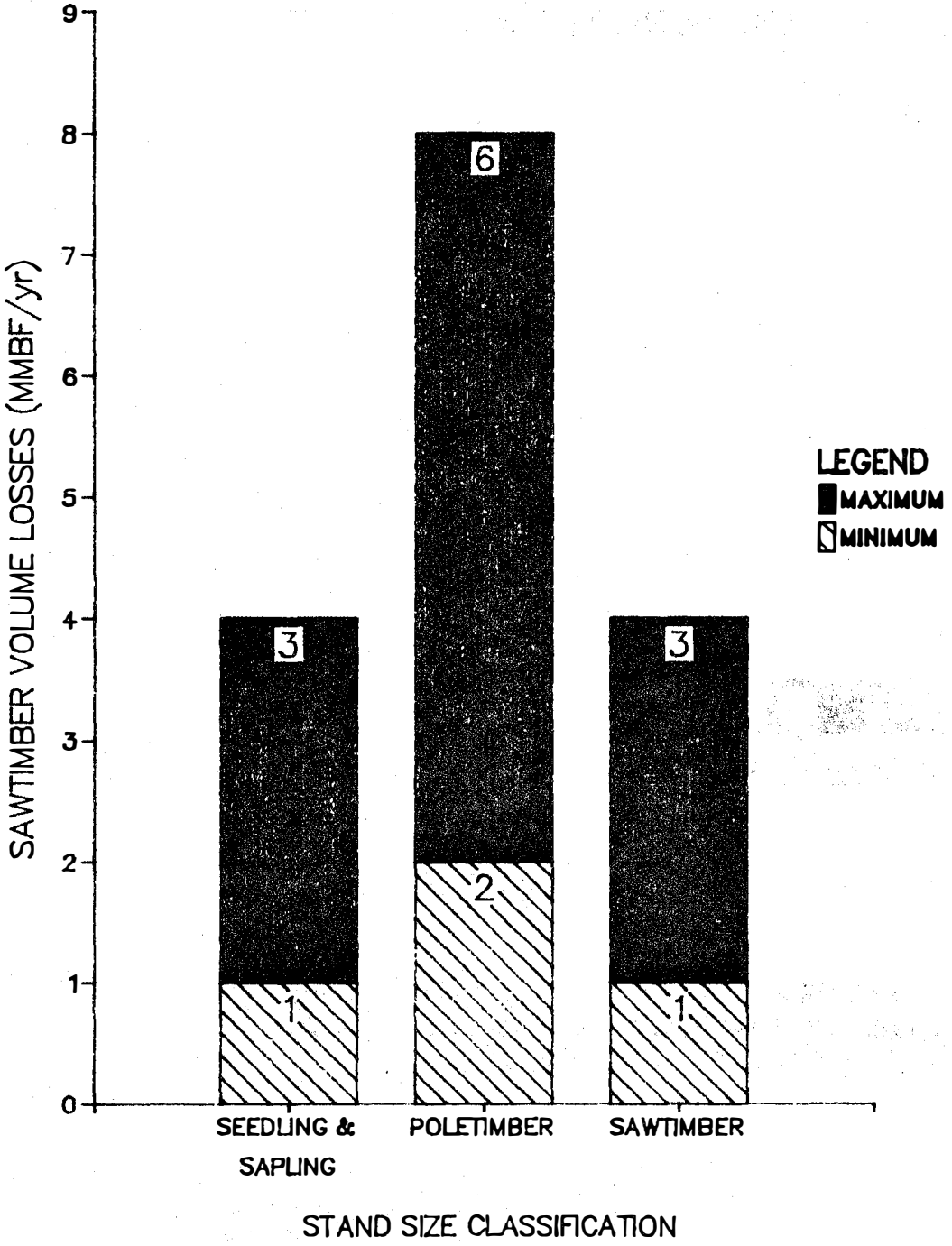
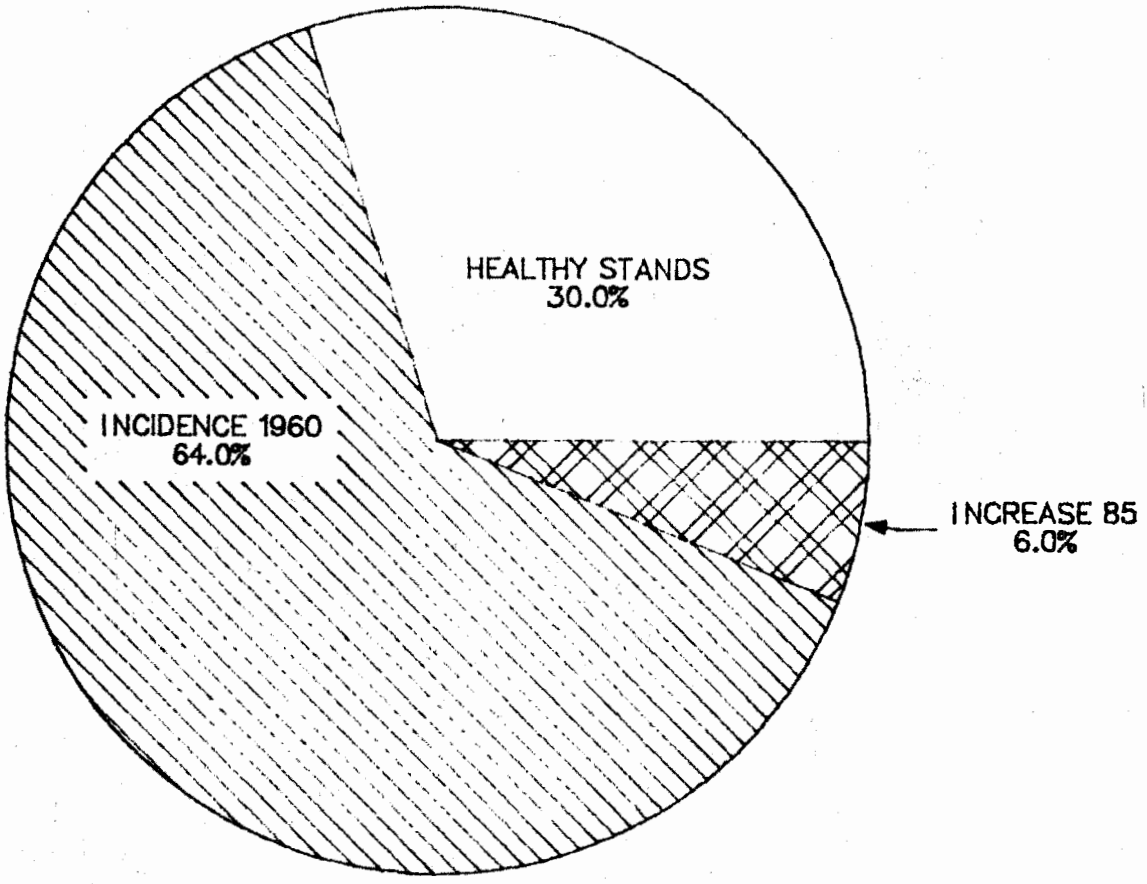


FIGURE 5. Increase in dwarf mistletoe incidence in commercial ponderosa pine stands on the Lincoln National Forest from 1960–1985




PROPORTION OF TOTAL NO. OF STANDS

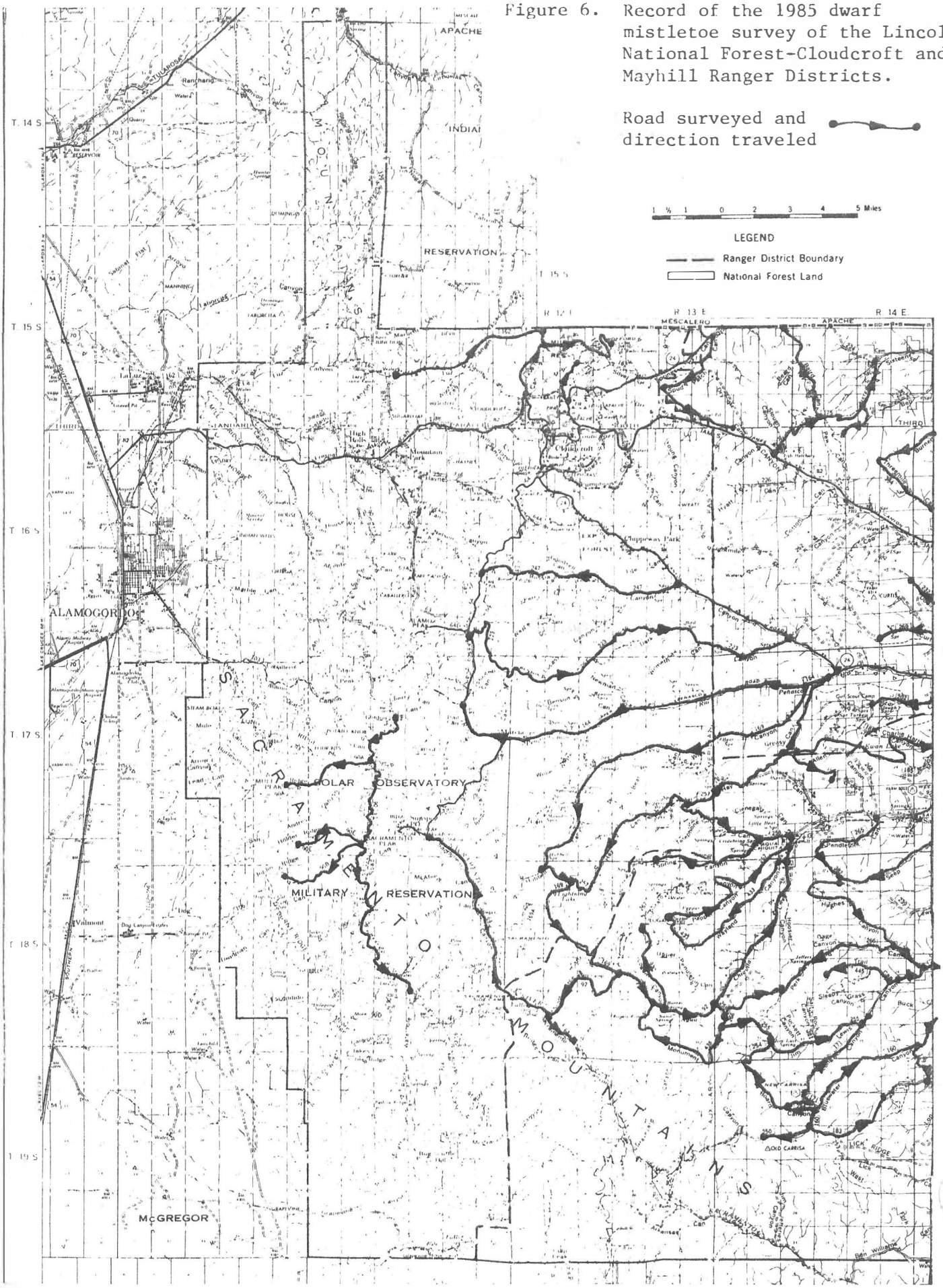



Figure 6. Record of the 1985 dwarf mistletoe survey of the Lincoln National Forest-Cloudcroft and Mayhill Ranger Districts.

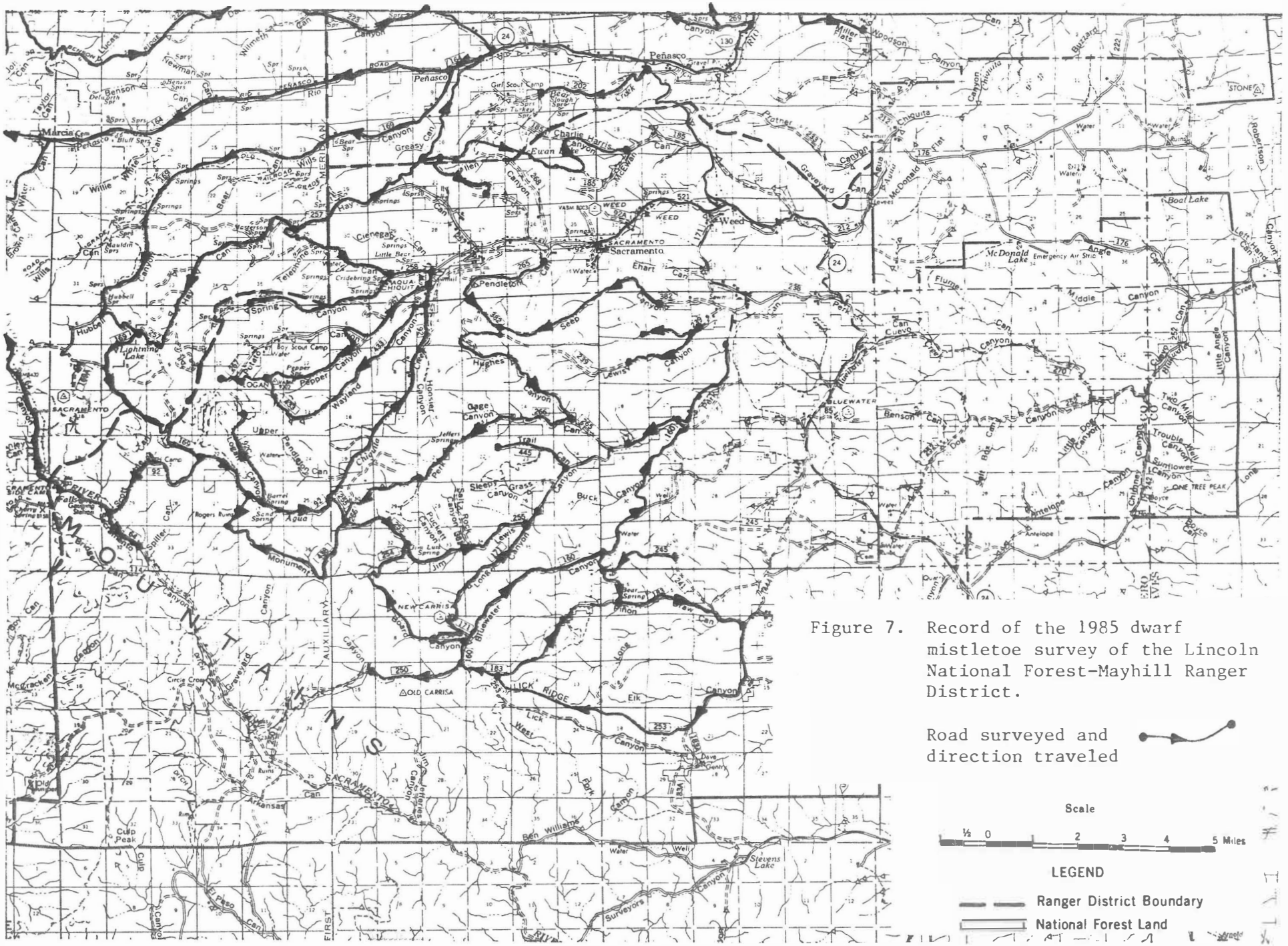



Figure 7. Record of the 1985 dwarf mistletoe survey of the Lincoln National Forest-Mayhill Ranger District.

Road surveyed and direction traveled

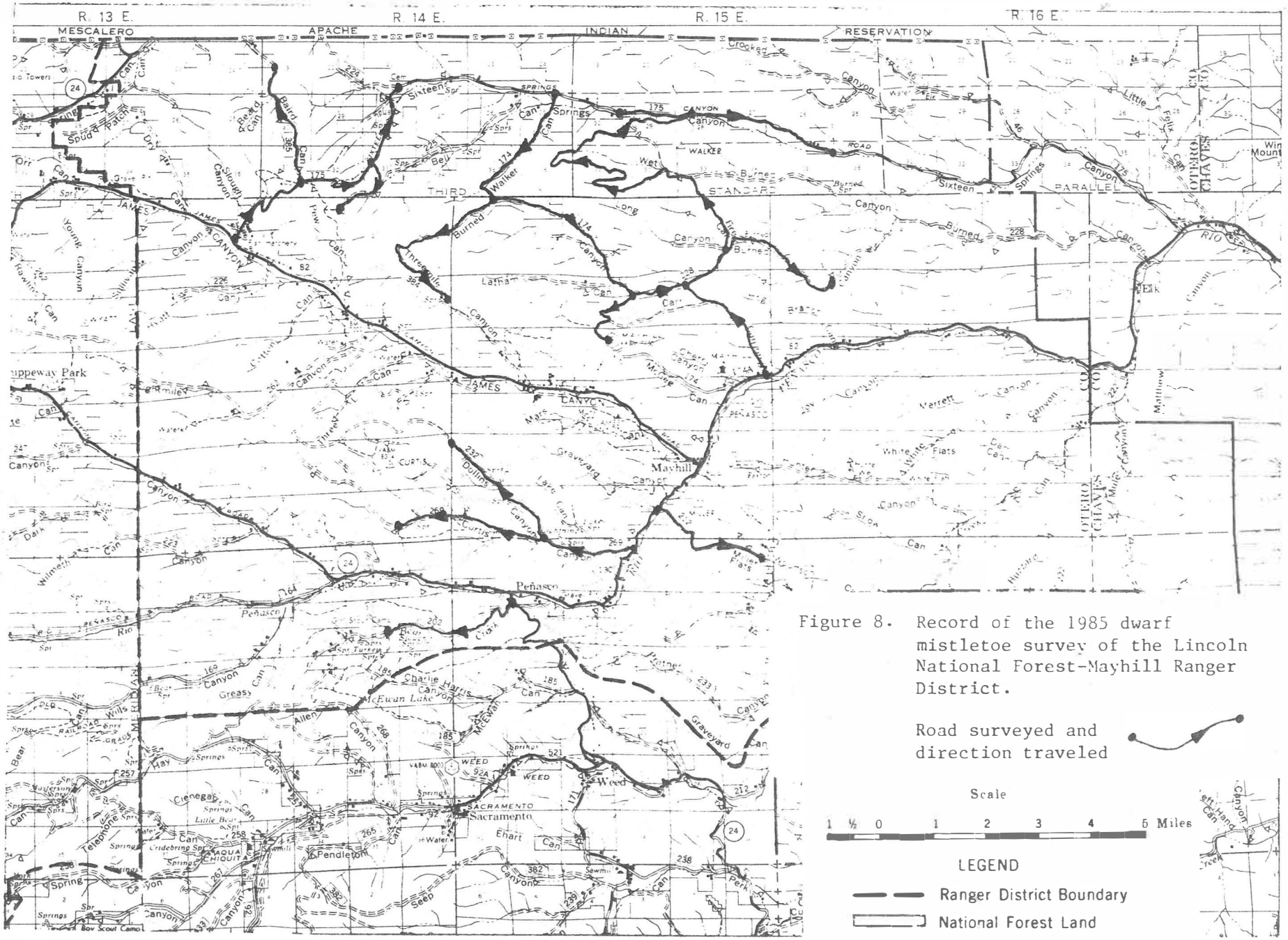



Figure 8. Record of the 1985 dwarf mistletoe survey of the Lincoln National Forest-Mayhill Ranger District.

Road surveyed and direction traveled

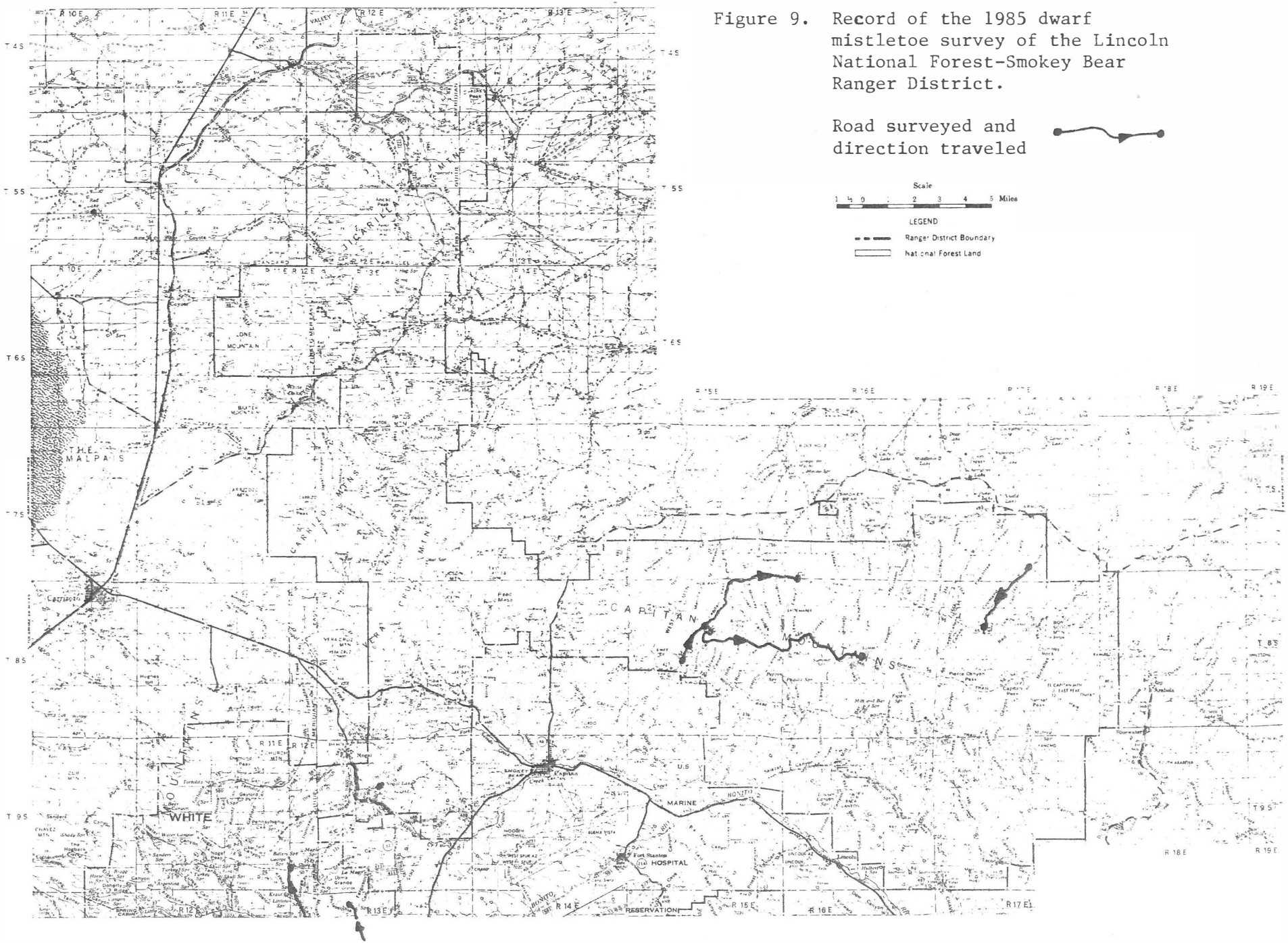



Figure 9. Record of the 1985 dwarf mistletoe survey of the Lincoln National Forest-Smokey Bear Ranger District.

Road surveyed and direction traveled

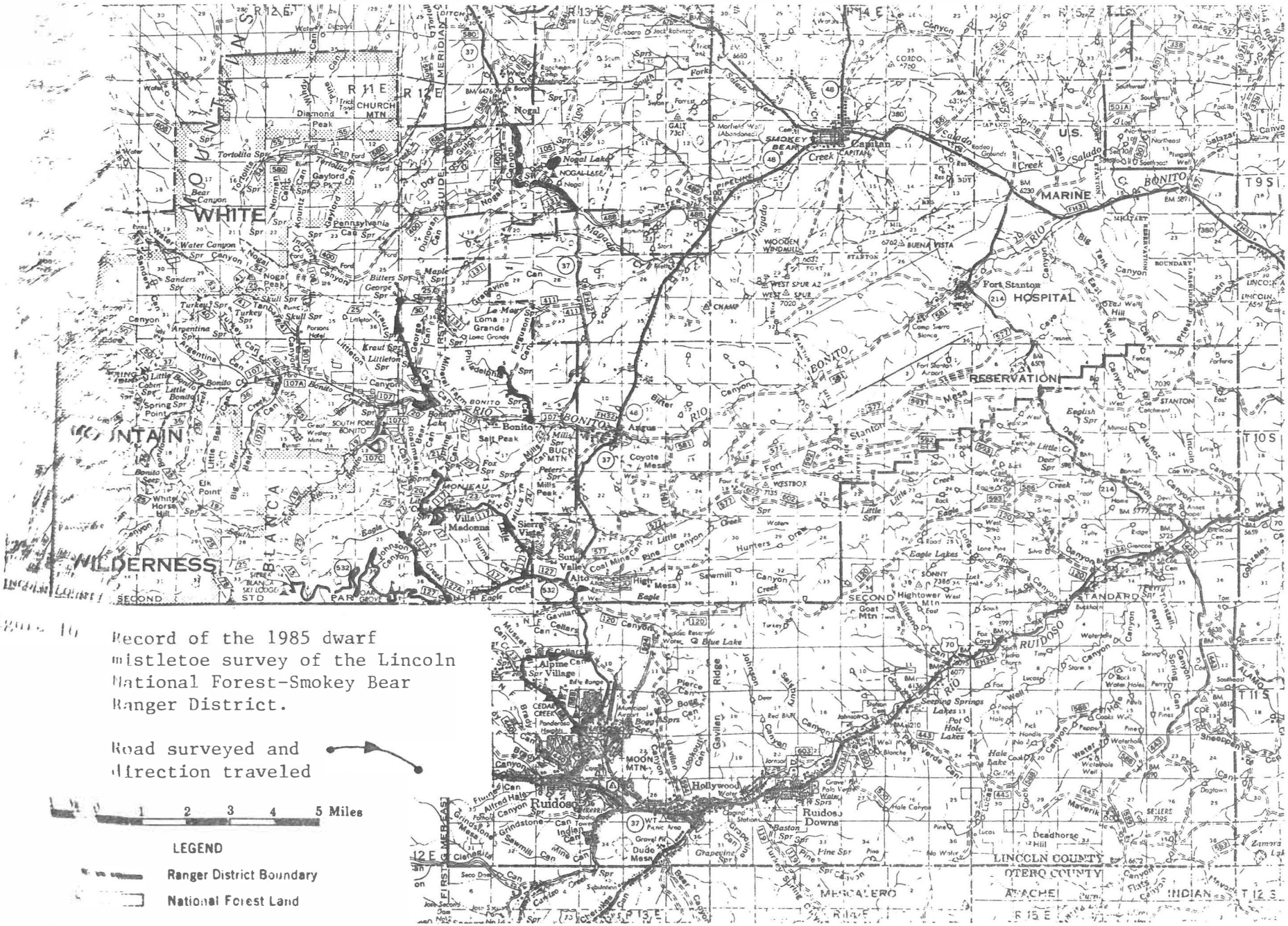



Figure 10. Record of the 1985 dwarf mistletoe survey of the Lincoln National Forest-Smokey Bear Ranger District.